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Danube Delta Coastline Dynamics in the Last 160 Years

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Wave-dominated deltaic coasts depend on the balance between wave climate and sediment supply, which controls the medium and long-term shoreline evolution. Interestingly, the common plan shapes of the wave-dominated lobes impose different wave exposures and longshore sediment transport magnitudes on the lobe flanks, characterized by ever changing aspects which make these sandy coasts some of the most mobile world coastlines. The Danube Delta coast consists of approximately 220 km (both Romanian and Ukrainian sectors) of tideless, medium-energy low-lying sandy beaches interrupted by multiple river mouths and, sometimes, by engineering structures (Sulina jetties and Midia harbour).

The objective of this study is to examine and explain the factors which have driven the Danube Delta coastline dynamics at multi-annual to multi-decadal and centennial time-scales. Our analysis is based on multiple shorelines extracted from historical and modern maps (since mid-19th century), recent medium to high resolution satellite images (since 1984), aerial photos (since 1969), GPS surveys (available after 1990) and LIDAR data (2011), which were comparatively analysed by means of GIS techniques.

Nowadays, more than half (~55%) of the Romanian Danube Delta shoreline (disposed in five littoral cells) is affected by erosion. The present coastline configuration is the result of the long-term evolution of this deltaic coast. Depending on the temporal and spatial scales taken into consideration, different driving forces changed the leading role in the dynamics of Danube Delta shoreline in the last 160 years. At centennial time-scale, the threefold decrease of Danube sediment discharge in the last century (especially after 1950, as a result of dams‘ construction in the Danube watershed) explains the significantly higher shoreline migration rates and area changes between 1856 and 1961/1979 in comparison with the subsequent period, especially along the accumulative sectors. For the Chilia prograding lobe, this resulted in the decrease with more than 75% of the progradation rates and with approximately 90% of the corresponding area change rates, marking its transition, since mid-20th century, from fluvial-dominated morphology to wave-influenced aspect and behaviour. Also, since the beginning of the 20th century, the asymmetric Sf. Gheorghe lobe (the other active lobe of the Danube), experienced dramatic changes of its millennial prograding pattern expressed by the complete cessation of the updrift coastal progradation and the prevalence of erosion in front of the river mouth, whose sediments are feeding far-positioned downdrift depocentres. These changes are reflected by the recent (1930s–present) river mouth dynamics, characterized by cessation of its long-term seaward expansion in favour of downdrift migration, indicating the transition of the Sf. Gheorghe mouth from an asymmetric to a deflected wave-influenced delta morphology.

At multi-decadal scale, different modes of climate variability (e.g. North Atlantic Oscillation) control the storminess variations along the Danube Delta coast. Hence, active storminess during 1961-1979 time interval determined very high shoreline dynamics, with two-three times higher shoreline migration rates than afterwards, when a decrease in storminess favoured less dynamic coastlines (on both prograding and erosive sectors). At inter-annual scale, waterline mobility is influenced by storm regime and river floods.

Our findings should support the sustainable coastal management and planning, providing a better understanding of past and present coastal processes along the Danube Delta coast.